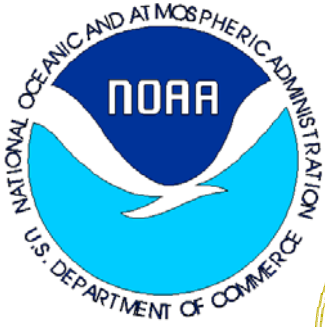


NEXRAD Technical Advisory Committee

NWS Perspective on New Science Implementation

Silver Spring, MD
May 21-22, 2002

NEXRAD Objective

Reduce loss of life, injuries, and property damage due to severe weather

- **Increase accuracy and resolution**
- **Provide Doppler wind information**
- **Improve data distribution to users**

(Joint Operational Requirements: 1981)

NWS Basic Questions

- **What key improvements in weather radar are required to take NWS services to the next plateau?**

- **What are the key areas to focus on in science and technology to support moving to the next radar plateau?**

From NWS Team to Formulate Tornado Warning Improvement Strategies
(Dennis McCarthy)

NEAR-TERM APPROACH 2002 – 2007

- **Focus on observational systems**
- **Enhance existing systems**
- **Optimize operations**
- **Increase MIC involvement**
- **Improve data assimilation and analysis**

From NWS Team to Formulate Tornado Warning Improvement Strategies
(Dennis McCarthy)

MOST URGENT TECHNOLOGY IMPROVEMENTS 2002 - 2007

- **WSR-88D upgrades**
- **AWIPS upgrades**
  - **Optimize performance**
  - **Accelerate LINUX migration**
- **Weather Event Simulator upgrades**
- **Integrate FAA radar data**
- **Data density increase (temporal/spatial)**
- **Data assimilation/analysis improvements**

From NWS Team to Formulate Tornado Warning Improvement Strategies
(Dennis McCarthy)

LONG-TERM APPROACH BEYOND 2012

- **Evolution of existing systems**
- **Phased array radar**
- **More focus on local/regional storm-scale models**
- **Fully integrated data assimilation**
- **More emphasis on outlooks/watches**

NWS Tornado Warnings Verification
(Dennis McCarthy Report)

		98	99	00	01	02	03	04	05	06	07
Lead Time	Actual	11	12	10	10						
Minutes	Goal	12	11	12	13	13	13	14	14	14	15
	Proposed					11	11	12	13	13	14
False Alarm	Actual	80	73	76	72						
(FAR)	Goal		72	65	73	72	70	68	66	65	64
	Proposed					71	70	70	69	69	68
Accuracy	Actual	66	70	63	67						
(POD)	Goal	68	70	70	68	69	70	71	72	73	74
	Proposed					69	70	71	73	73	74

Summary Findings

- **Three separate statistical models arrive at similar conclusions - slow positive trend to 11 minutes**
- **Proposed improvements in 02 and 03 supported by statistical trend**
- **Steady improvement beyond statistical trend forecasted for 04 – 07**

Rationale for Improvements

- **New training (e.g Weather Event Simulator) and optimizing warning operations will improve forecaster skill**
- **In 02/03, AWIPS LAN and workstation improvements will improve display and timeliness of data**
- **In 03/04, ORPG will provide new volume coverage patterns, higher resolution data, and improved product update frequency will improve resolution and timeliness of data to forecasters**
- **In 03, integration of FAA radar data, including TDWR, into AWIPS will also improve detection and coverage**
- **In 05, ORDA will improve velocity and reflectivity, improving accuracy**

NEXRAD Product Improvement

Vision:

Keep NWS weather radar operations as close to state of the science as possible

Specific Goals:

- **Improve tornado, severe thunderstorm and flash flood warnings**
- **Provide open architecture for improved science and technology insertion**
- **Enhance general use of weather radar data in both the government and private sectors**
- **Reduce costs for maintenance and growth of the radar system**

NEXRAD Product Improvement

Current and Planned Projects:

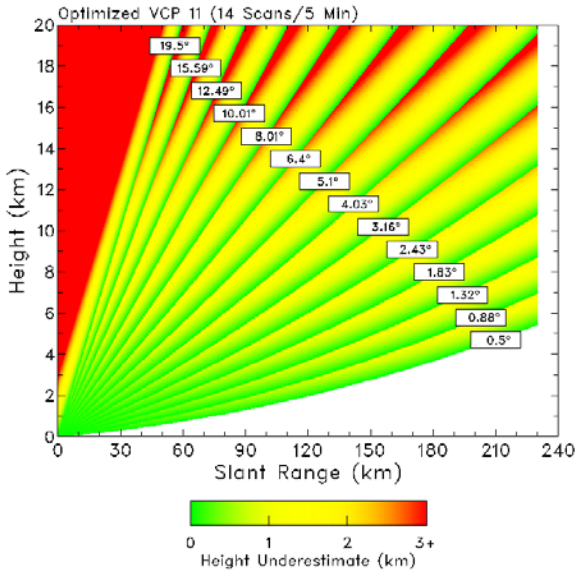
- **Open Systems Radar Product Generator (ORPG)**
  - Replace 10-year old, proprietary computers with modern, open architecture workstations
  - Implement new science algorithms on a regular basis
- **Open Systems Radar Data Acquisition (ORDA)**
  - Replace 10-year old computer and signal processor with open architecture, workstations, and modern DSPs
  - Mitigate range/velocity ambiguity
  - Improve areal and temporal resolution of data collection
- **Dual Polarization (Dual Pol)**
  - Add linear, vertical polarization channel
  - Derive polarimetric variables for scientific processing

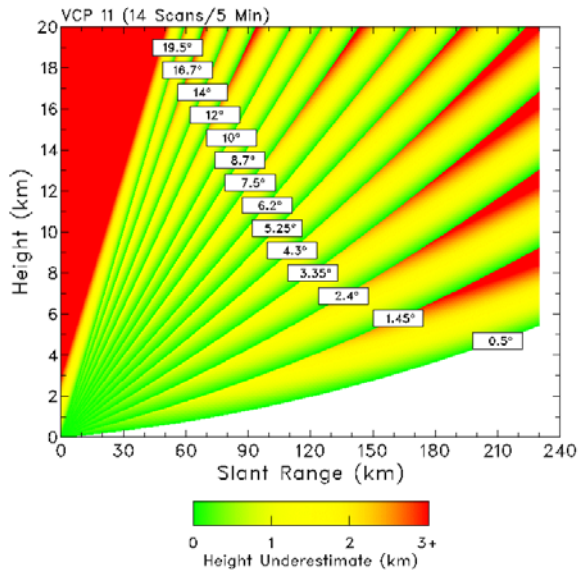
Improve Small Tornado Warnings

<u>Data Quality</u>:

Increase resolution

- **Full data resolution products (ORPG)**
- **More low angle slices (ORPG)**

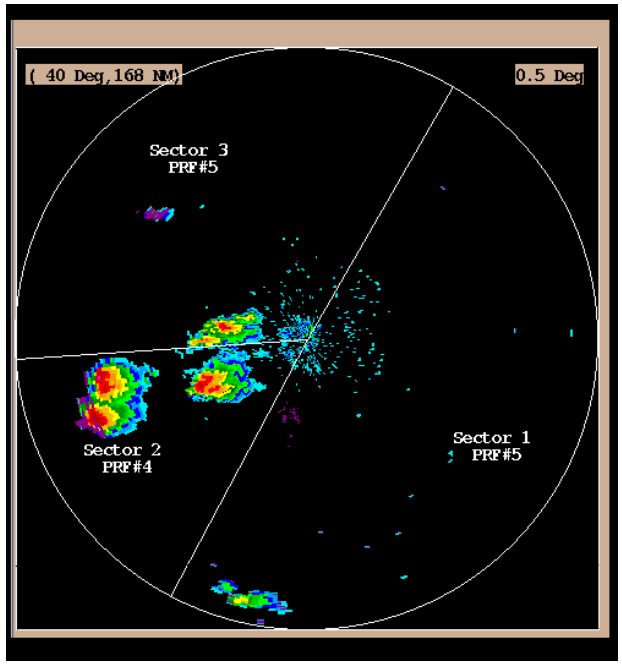




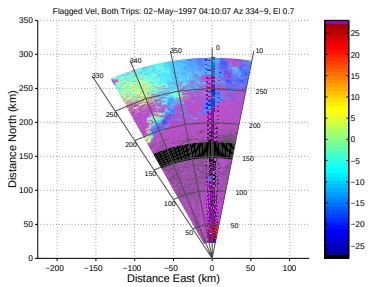
Improve Small Tornado Warnings

Data Enhancements:

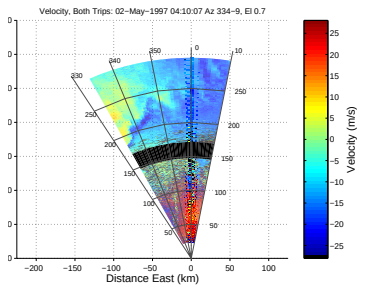
- **Mitigate range and velocity folding**
  - **Better user control of PRFs (ORPG)**
  - **Dual scans at same elevation angle, with different PRTs (ORPG)**
  - **Phase coding (ORDA)**
  - **Staggered PRTs (ORDA)**



ORPG Graphical User Interface for selection of best PRF to remove range folding from a given storm



Current Velocity data with extensive range folding (purple haze)

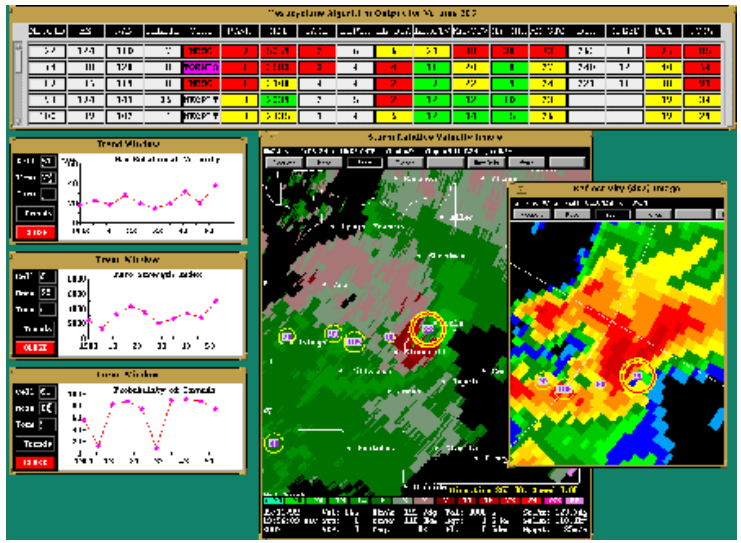


Retrieval of Velocity data with phase coding technique

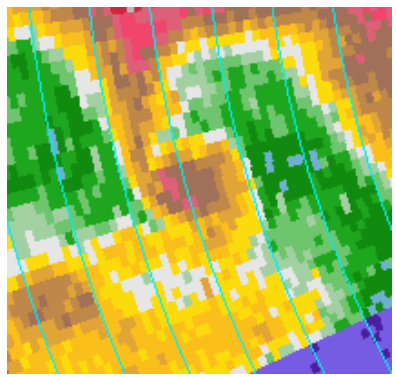
Improve Small Tornado Warnings

Improved Science:

- **Improved mesocyclone algorithm (ORPG)**
- **Immediate output of algorithm rotation indication (ORPG)**
- **Improved displays for small scale tornado signatures (ORDA, ORPG, AWIPS)**

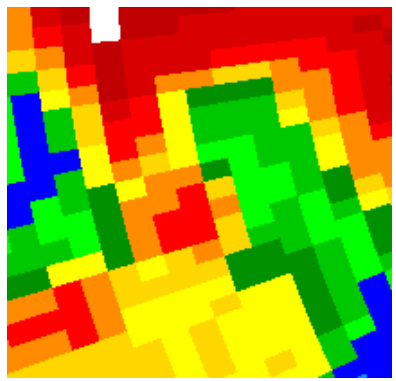


NSSL new Mesocyclone Algorithm



ORDA Reflectivity:

0.5° x 0.25 km



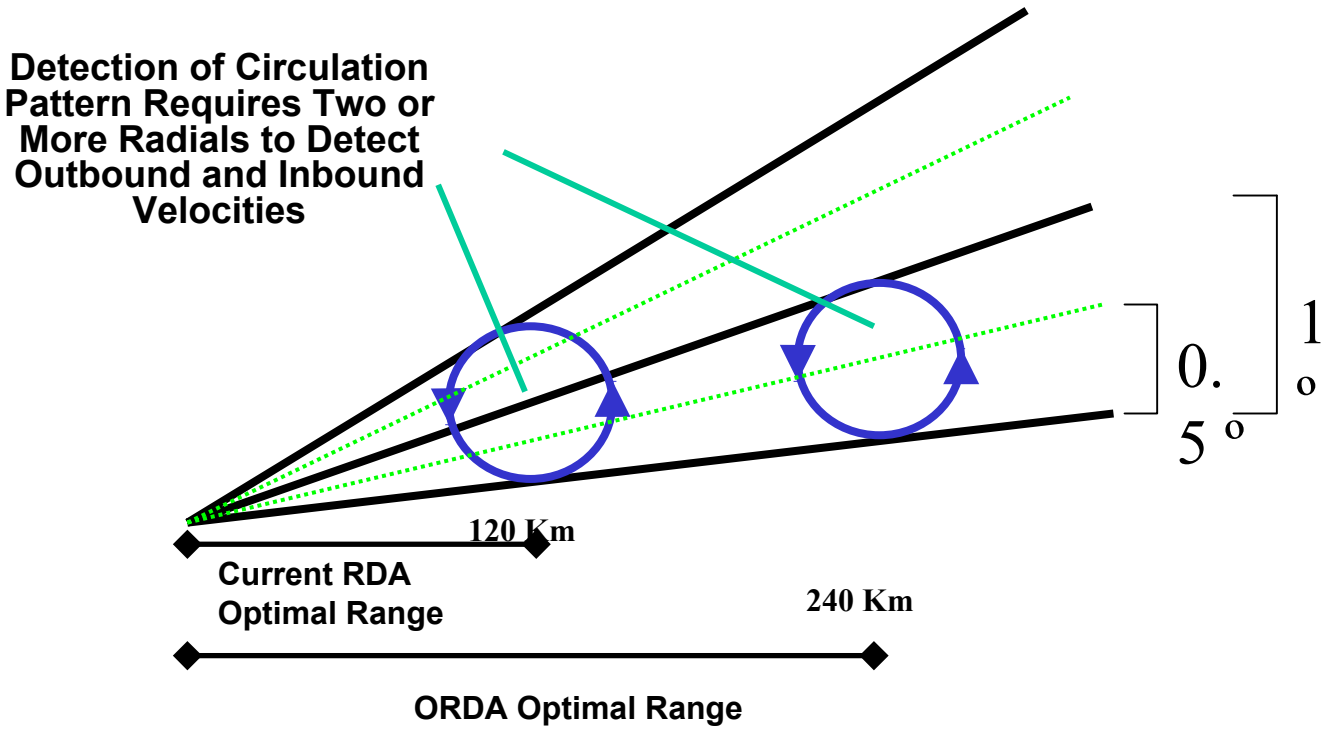
Current Reflectivity:

1.0° x 1.0 km

Improve Small Tornado Warnings

Data Quality:

- **Increase resolution**
  - **1/2 deg azimuth samples (ORDA)**

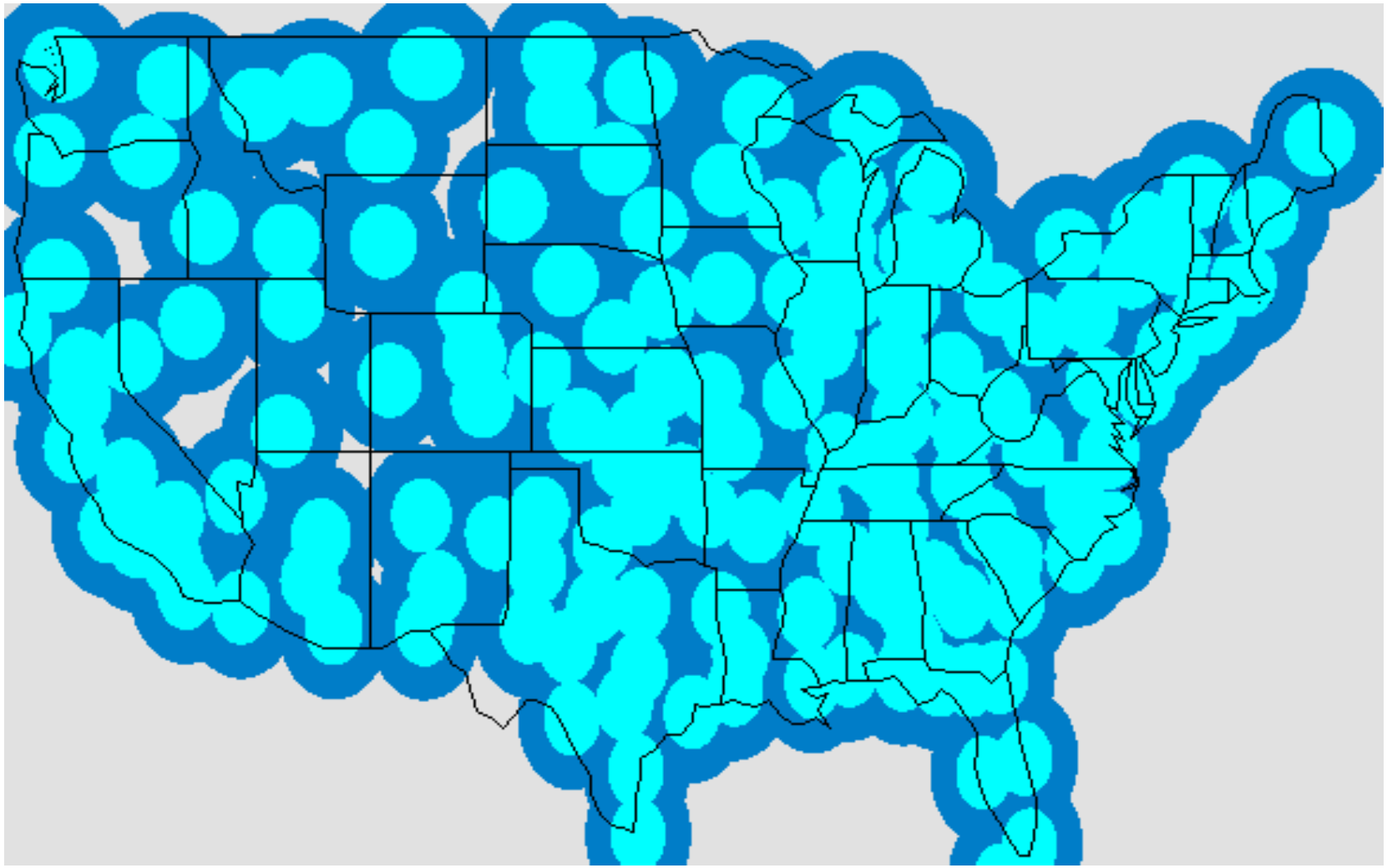


Increased Area for WSR-88D Detection of Small Tornadoes

Based on 4 km Average Size of Mini-Super Cell Circulation: NRC Report

Current RDA 1 Deg Sampling

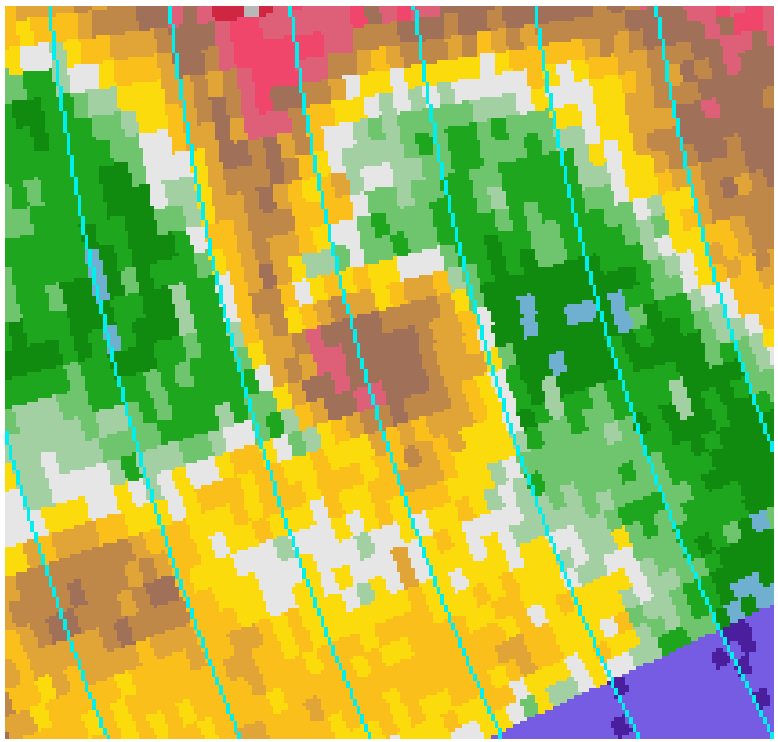
ORDA ½ Deg Sampling



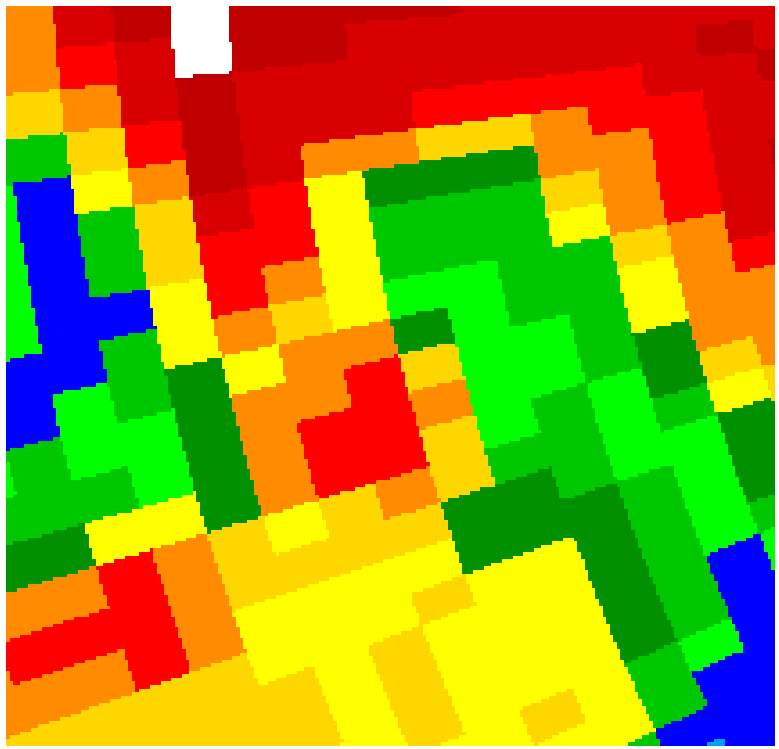
Improve Small Tornado Warnings

Data Quality:

- **Increase resolution**
  - **1/4 km range resolution for reflectivity (ORDA)**



ORDA Reflectivity: 0.5° x 0.25 km

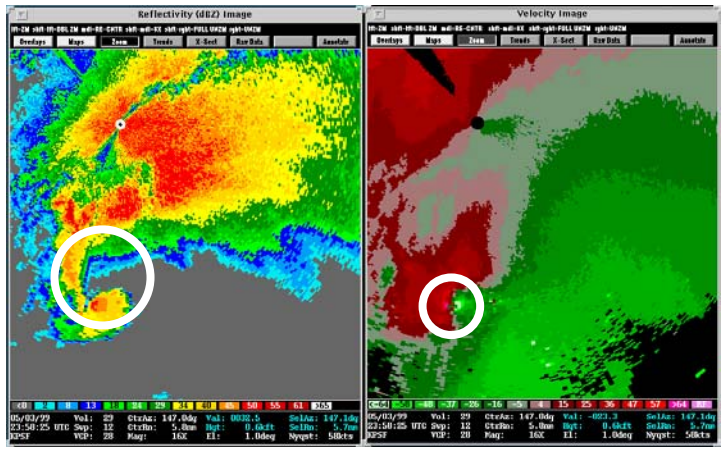


Current Reflectivity: 1.0° x 1.0 km

Improve Small Tornado Warnings

Utilize FAA Radar Data:

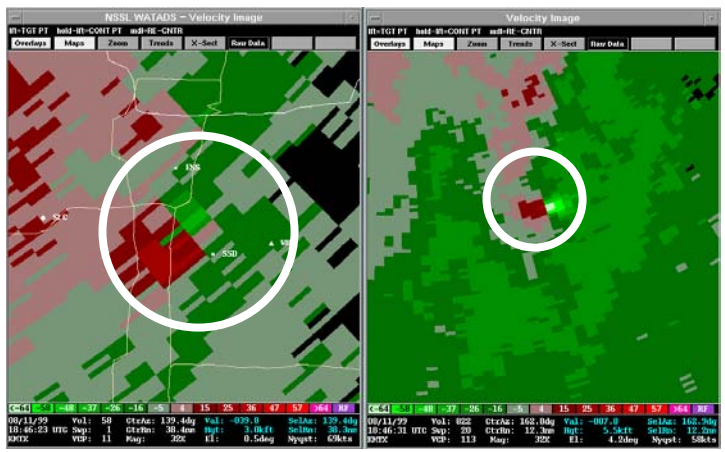
- ORPG ingest and product generation
  - Backup when WSR-88D out of service (ORPG)
  - May have best view of storm (ORPG)
  - May offer confirmation of WSR-88D indications (ORPG)



Oklahoma City
May 3, 1999

Reflectivity Hook

Velocity Rotation Signature



Salt Lake City
Aug 11, 1999

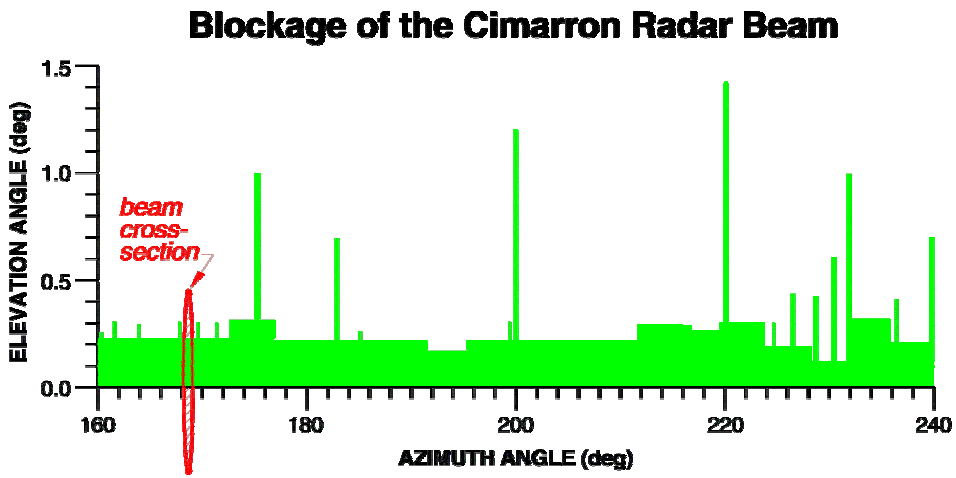
Current NEXRAD, diffuse rotation signature

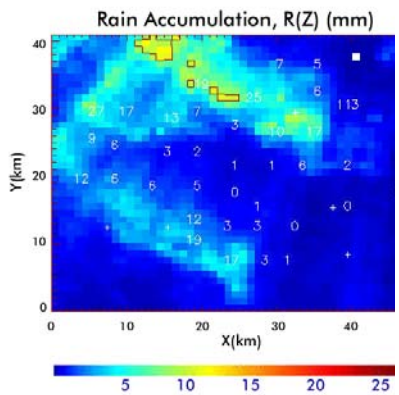
Higher resolution FAA TDWR, well defined rotation

Improve Rainfall Estimation

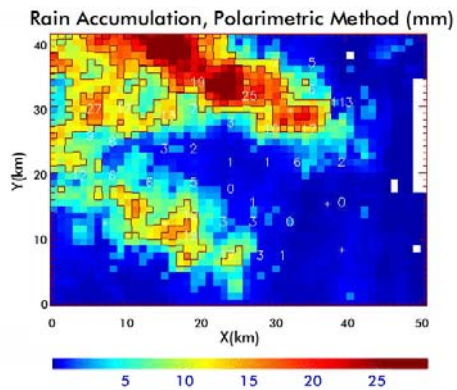
Improved Data Quality:

- Valid rain rate estimation in shadow of partial beam blockage (Dual Pol)
  - Polarization parameters are valid even though reflectivity values are severely attenuated





Rainfall rates estimated
From attenuated reflectivity

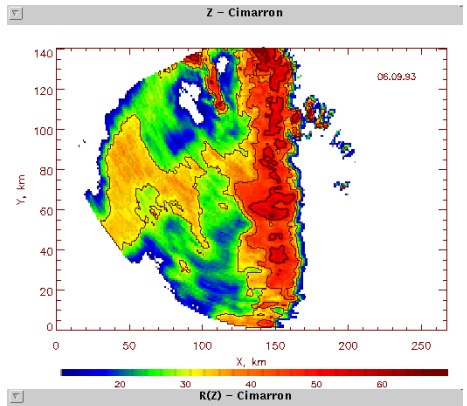


Rainfall rates estimated
from dual polarization data

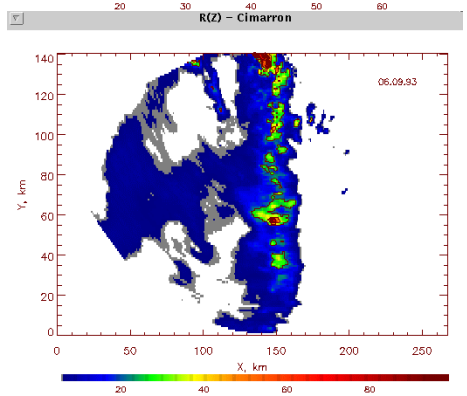
Improve Rainfall Estimation

Improved Data Quality:

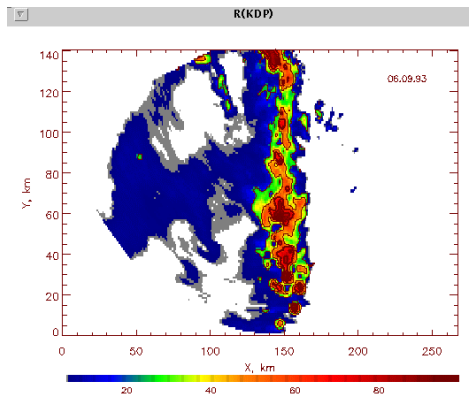
- **Reduced impact of attenuation by heavy rain (Dual Pol)**
  - **Polarization parameters are valid even though reflectivity values are attenuated**



Long radial extent of heavy rainfall



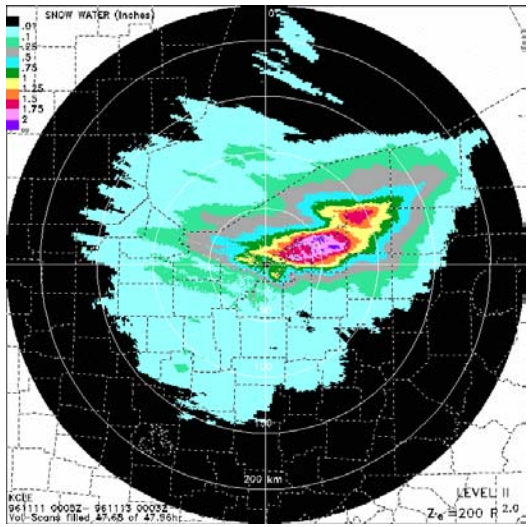
Rainfall rates estimated from attenuated reflectivity



Rainfall rates estimated from dual polarization data

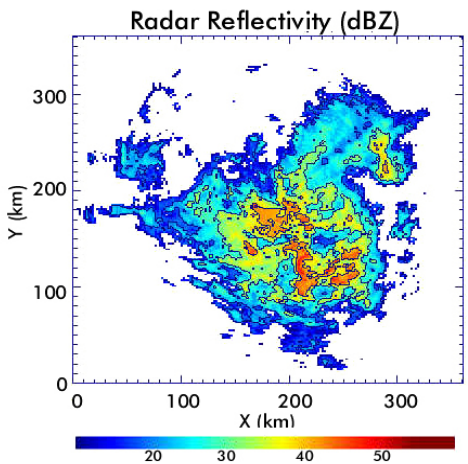
Provide Winter Products

- **Snowfall Accumulation and Liquid Water Equivalent (ORPG)**

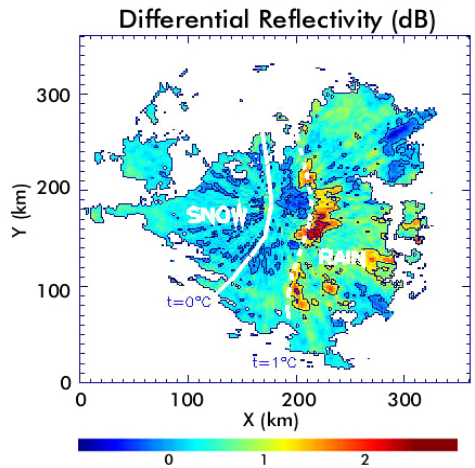


Prototype Snow Liquid Water Equivalent Product

- **Rain/Snow line (Dual Pol)**
  - **Snowflake targets can be distinguished from rain**



All precipitation types have similar appearance



Precipitation types have differing returns

Science & Technology Evolution ORPG

Legacy	ORPG
• 16-level data resolution for products	• 256-level (full) resolution products
• Algorithm indications of severe weather (TVS, MESO) at end of VCP	• Intermediate output of products as soon as criteria met—gain of 2-3 min
• Limited number of products sent to AWIPS over narrow band link	• Unlimited sharing of information between ORPG & AWIPS over LAN
• Fixed, limited number of vertical layer products	• User-selectable, freezing-level and other layers
• Fixed, limited number of VCPs	• New VCPs, e.g., more tilts at lower angles to improve vertical resolution
• No snowfall algorithm	• Snowfall and liquid water equivalent
• No incorporation of rainfall rate bias	• AWIPS bias calculation fed to ORPG
• No bright band mitigation	• Bright band and range bias mitigation
• Original Mesocyclone algorithm	• Improved NSSL Meso Algorithm
•No ingest or use of FAA radar data	•Products generated from FAA data

Science & Technology Evolution ORDA

Legacy	ORDA
•Extensive range folding	•Mitigate range/velocity folding
•Reflectivity resolution of 1 km	•Increase resolution to ¼ km
•Velocity processing to 230 km	•Extend processing through 2nd trip
•Data sampling at 1 deg increments	•Increase resolution to ½ deg increments
•Single set of clutter filters for all users	•Multiple streams of base data, varying filtering
•Signal to Noise threshold filtering at RDA	•No SNR filtering at ORDA, values sent to ORPG for adaptive use by different programs
•Errors in calculation of Spectrum Width	•Corrected Spectrum Width for better turbulence algorithm performance
•Reflectivity data from low angle Doppler scans, and Doppler data from low angle surveillance scans discarded	•All data processed and sent to ORPG
•Level II archive location restricted to RDA	•Level II archive can be moved to Offices, affording more reliable operation

Science & Technology Evolution
Dual Polarization

- **Improve precipitation estimates**
  - **Reduced attenuation from long radial extents of heavy rainfall**
  - **Discriminating rainfall from hail, clutter, birds, etc**
  - **Obtaining accurate estimates from 'partial beam blockage' areas**
- **Discriminate hail from rain; possibly gauge hail size**
- **Discriminate among dry/wet snow, sleet, rain in winter storms**
- **Remove bird impacts from velocity estimates: improve VAD Wind Profiles**
- **Identify chaff**

FAA Radars Exploitation

The NEXRAD radar network provides excellent weather information over the United States. The FAA processes weather information from its Air Traffic Control radars that could provide valuable complementary data for:

- **Coverage in cases of NEXRAD outages**
- **Closer or unobstructed views of particular storms**
- **Complementary coverage in fringe areas of NEXRAD data**
- **Wind field calculations combining data from all radars**